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B5N N77X N764 N757 N735 N694 N693 N692 N671 N667 N661 N658 N655 N649 N648 N644 N643 N639 N61Y N607 N603 N599 N593 N59Y N589 N572 N519 N518 N514 N510 N508 N507 N498 N497 N46X N42Y N418 N417 N401 N389 N237 N225 N223 N21Y N207 N196 N195 N77X N764 N757 N735 N694 N693 N692 N671 N667 N661 N658 N655 N649 N648 N644 N643 N639 N61Y N607 N603 N599 N593 N59Y N589 N572 N519 N518 N514 N510 N508 N507 N498 N497 N46X N42Y N418 N417 N401 N389 N324 N32Y N252 N226 N224 N211 N207 N20Y N199 N77X N764 N757 N735 N694 N693 N692 N671 N667 N661 N658 N655 N649 N648 N644 N643 N639 N61Y N607 N603 N599 N593 N59Y N589 N572 N519 N518 N514 N510 N508 N507 N498 N497 N46X N42Y N418 N417 N401 N389 N324 N32Y N252 N226 N224 N211 N207 N181 N180 N176 N175 N2734 N2702 N2520 N2304 N2302 N1704 N1520 N1514 N1506 N0520 N0518 N0108
F2P P1B7W P1B7F P1B5D P1B5B P1A9 P1A36 PC27
U1S S1144 S1403 S1508 S1573 S1820 S1990 S2013 S2055 S2314 S3048

(56) Documents cited
DD 0213597 A

(58) Field of search
UK CL (Edition K) B5N, F2P, F2X
INT CL$^5$ A62D, B32B, F16L, H02G
Online databases: WPI: CLAIMS.

# (54) A flexible sheet material

(57) A flexible sheet material suitable for use as a barrier in resisting heat transfer from a source of radiant heat comprises a layer of silicone elastomer (2; 12) which may be foamed, and a metallic foil (3:14) less than one micron in thickness applied to one surface of the elastomer by transferring the foil from a supporting substrate. The elastomer layer may be formed on a knitted, braided or woven support (1; 10). Clothing as well as tubes may be made from the flexible material.

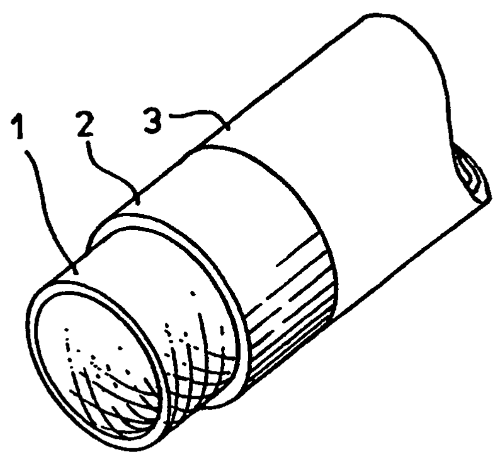


FIG.1

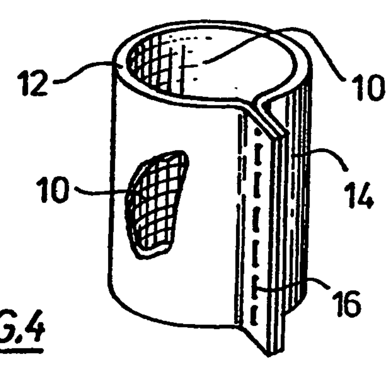


FIG.4

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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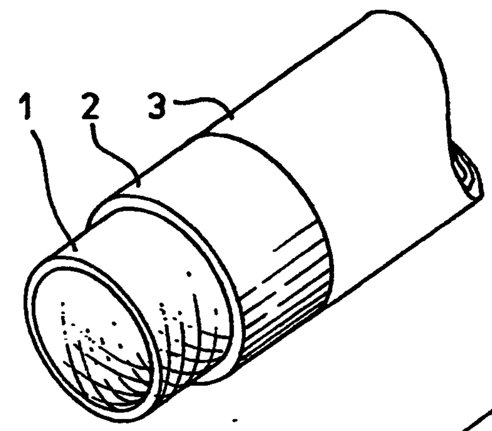


FIG.1

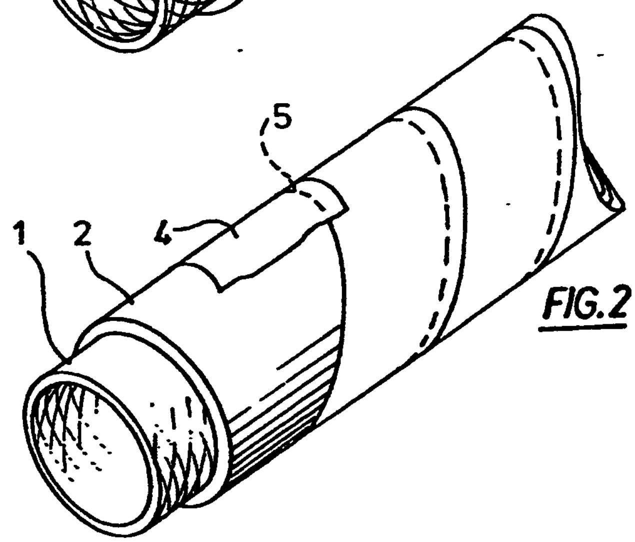


FIG.2

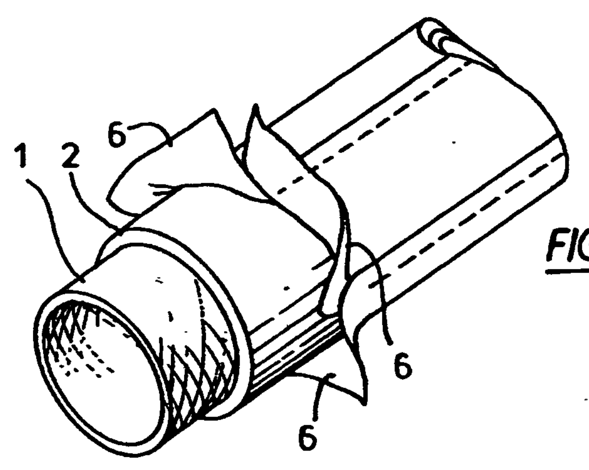


FIG.3

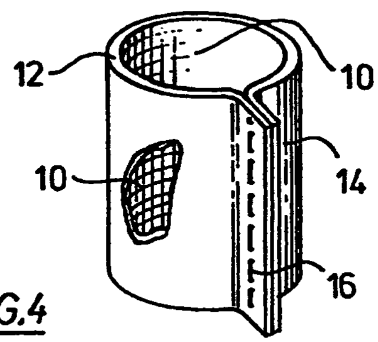


FIG.4

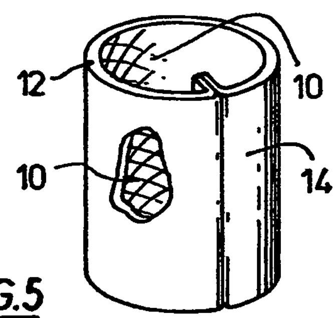


FIG.5

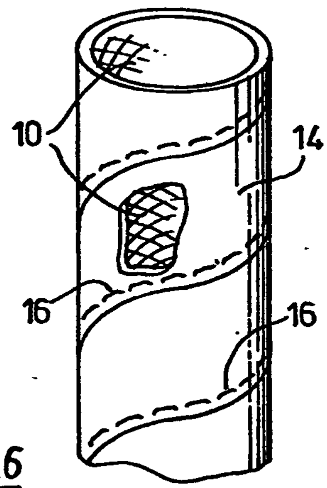


FIG.6

## Flexible sheet material

This in invention is concerned with a method of making flexible sheet material suitable for use as a barrier for resisting heat transfer from a source of radiant heat, and with items, eg tubes or clothing, which are made from such sheet material.

In many circumstances, the requirement arises for a flexible sheet material which can be used for resisting heat transfer from sources of radiant heat, namely sources of infra-red radiation. For example, such sheet material may be formed into flexible tubing of the kind commonly used to protect components such as electrical wiring, brake and fuel lines from heat, particularly the heat sources found in automotive engine compartments. Such tubing is often, but not always, a textile product. Important requirements for such tubing are flexibility, which for present purposes includes the ability to bend, ability to stretch

circumferentially, shape retention and ease of installation, together with ability to resist heat transfer to the substrate to be protected. As another example, such sheet material may be formed into articles of clothing for use by fire fighters or others who have to enter hot environments. In this case, flexibility and shape retention are important requirements. Such flexible sheet materials may, in addition to their ability to keep items cool, alternatively be used to keep items warm by resisting heat transfer away therefrom.

Resistance to heat transfer is predominantly a function of reflectivity; the most important heat transfer mechanism is radiation at infra-red wavelengths. Whilst high visual wavelength reflectivity sometime suggests good infra-red reflectivity, this is not necessarily the case, since some materials which appear highly reflective to the eye are in fact good absorbers of infra-red radiation. One known technique, with tubing to protect electrical wiring and brake or fuel lines, is to envelop the tubing in a layer of aluminium foil, by wrapping either spirally or longitudinally with a strip of foil. Typically the foil is at least 20 microns in thickness. The foil is retained in place by adhesive or by stitching. The resultant product has good reflectivity, but suffers from severely impaired flexibility. Another, more recent technique, is to coat the tubing with a layer of flexible polymeric material containing metallic particles, preferably in the form of

flakes, for example, of aluminium. Whilst this gives reasonable good flexibility, the infra-red reflectivity is not as good as might be expected from the properties of an individual flake. It is thought that the reasons for this are the particulate nature of the metal allowing gaps to exist between flakes, allied to absorption by the polymeric material, both before reflection and after, since the particles do not constitute the surface layer, which is predominantly polymeric.

It is an object of the present invention to provide a method of making a sheet material suitable for use as a barrier for resisting heat transfer from a source of radiant heat and which combines good reflectivity with good flexibility.

The invention provides a method of making a flexible sheet material suitable for use as a barrier for resisting heat transfer from a source of radiant heat, the method comprising forming a layer of a silicone elastomer and bonding a metallic foil less than one micron in thickness to one surface of the layer by transferring the metallic foil to the elastomer layer from a supporting substrate.

A sheet material made by a method in accordance with the invention has good flexibility, good reflectivity, and good shape retention.

The metallic foil may be bonded to the elastomer layer by means of adhesive or by making use of the adhesive qualities of the elastomer before it has solidified.

The elastomer layer may be formed on a knitted, braided or woven fabric support which increases the strength of the sheet material. Where the fabric support is woven and where the sheet material is subsequently formed into a tube, the length of the tube may be arranged to extend at substantially 45 degrees to the direction of the weft of the weave. This has been found to increase the flexibility of the tube. The fabric support may be formed from glass fibre, aromatic polyamide fibre or regenerated cellulose fibre, including blends thereof.

The elastomer is preferably a silicone rubber and may be foamed before or after bonding the foil thereto. The metallic foil is preferably or aluminium and may be less than 0.01 microns thick. In practice, thicknesses of from 2 to 4 nanometres have been found to be satisfactory.

It has also been found that the use of a foamed elastomer on a knitted, braided, or woven fabric support tends to smooth out the surface irregularities of the support, thereby ensuring a relatively smooth surface for the foil itself. Surface smoothness is a factor in obtained a good reflectivity.

Suitable foils of aluminium are available on a thin polymeric support film, usually of a polyester material. The foil is usually provided with an adhesive coating on the exposed surface of the aluminium. The support film is removed during or after transfer of the foil to the surface of the elastomer layer.

The silicone elastomer layer may be applied to the foil prior to application to a knitted, braided, or woven fabric support. The elastomer layer will usually be applied as a liquid which is dried, cured or otherwise caused to solidify in situ on the support. However, if the elastomer layer is not sufficiently adhesive to retain the foil, then an adhesive interlayer may be applied if one is not already present on the aluminium surface. However, it will normally be more convenient to use the elastomer itself for this purpose.

The silicone elastomer may also be applied to the textile substrate, prior to transferring the aluminium foil thereto, as is further discussed below.

Surprisingly, it has been found that, although the preferred metallic foils are so thin that in some cases they are actually translucent, they are highly effective reflectors of infra-red radiation. Their extreme thinness enables them to stretch or otherwise distort without rupture and without significant effect on the flexibility

of the sheet. They provide an essentially unbroken surface which is highly reflective to infra-red radiation.

However, the thinness of the foil does impart some vulnerability to abrasion damage. This may be minimised by at least three methods. The first is to apply a thin protective coating of a polymer having good infra-red transparency. The second is to deliberately conform the foil to the undulating surface of the sheet so that most of it lies in shallow depressions in that surface; it will be appreciated that this is especially applicable to textile fabrics. Thirdly, the elastomeric layer is preferably foamed, as mentioned earlier. This has the effect of imparting some resilience, as well as a degree of thermal insulation, which may be valuable for some end uses.

Where foil is to be applied to a fabric support constituted by tubing formed directly by braiding, circular knitting or by other means, the foil (on its support film) may be applied in several ways. For example, it may be helically wound, using a relatively narrow strip, or strips. It may be applied in a longitudinal direction using one or more strips extending lengthwise of the tube. This method is directly analogous to that used in the manufacture of cigarettes, where a single endless strip is progressively curled about an endless substrate by passage through one or more forming dies. This latter method is preferred, in the interests of simplicity. It has been observed that as long

as the overlaps between adjacent helical turns or between adjacent edges of the strip or strips are reasonably narrow, the support film may be removed without significant damage to the foil. Alternatively, the foil may be applied to a flat sheet and the sheet then formed into a tube, with the edges being sewn, adhesively bonded or otherwise joined.

Where the elastomer layer is formed on a knitted, braided or woven fabric support, it will not normally be significantly thicker than a surface coating and indeed it may not be in contact with (bonded to) much more than the adially outermost yarn surfaces. Otherwise impregnation/coating may tend to affect the flexibility. Whilst the elastomer could be applied to the support in a separate operation prior to application of the foil, it is preferred that it is applied to the foil, so that elastomer and foil layers are applied to the support together.

The invention also provides a flexible, predominantly textile fabric tube and further includes fabrics and articles of clothing made of material made by a method in accordance with the invention.

The invention also provides a flexible tube suitable for use as a barrier for resisting heat transfer from a radiant heat, the tube being formed from a flexible sheet material which comprises a layer of silicone elastomer formed on a

woven fabric support, and a metallic foil less than one micron in thickness bonded to the exposed surface of the elastomer layer, the length of the tube extending at substantially 45 degrees to the direction of the weft of the woven fabric support.

In order than the invention be better understood, preferred embodiments of it will now be described by reference to the accompanying drawings which:

Figure 1 is a perspective view of a first tube made by a method according to the invention, partly cut away to show its construction;

Figure 2 is a perspective, partly cut away view of a second tube made by a method according to the invention;

Figure 3 is a perspective, partly cut away view of a part of a third tube made by a method according to the invention;

Figure 4 is a perspective view of a fourth tube formed from a sheet material made according to the invention;

Figure 5 is a perspective view of a fifth tube formed from a sheet material made according to the invention and

Figure 6 is a perspective view of a sixth tube formed from a sheet material made according to the invention;

Referring to the Figures, Figure 1 shows a tube constituted by a glass fibre braid 1 with an elastomer coating 2 onto which is bonded a metallic foil 3 less than 1 micron thick.

Figure 2 illustrates one method of applying the foil by helically wrapping with a continuous strip 4, as will shortly be described in relation to Example 1.

Figure 3 illustrates a further method of applying the foil, this time by applying it as a series of longitudinally extending strips, 6.

Figure 4 shows a tube manufactured from a woven glass fibre fabric 10 in which the weft fibres extend longitudinally of the tube. It will be appreciated that the warp and weft structure of the fabric 10 is shown schematically; in ordinary circumstances the warp and weft would be much closer together. A layer of foamed silicone rubber 12 is formed on the fabric 10 and a metallic foil 14 less than one micron thick is bonded to the layer 12. The tube is formed by first forming a planar sheet comprising the fabric 10, the layer 12, and the foil 14 and bending the sheet to bring opposite edges together into overlapping relationship. The edges are then sewn together by stitches 16.

Figure 5 shows a tube which differs from that of Figure 4 in that the warp/weft fibres of the woven fabric 10 extend at substantially 45 degrees to the longitudinal directional of the tube thereby imparting greater flexibility. Furthermore, the sheet material is bent into the tube in the opposite sense to the tube of Figure 4, with the woven fabric 10 on the outside, and, after sewing through the overlapping edges, the tube is turned inside out to bring the foil 14 to the outside.

Figure 6 shows a tube which is made by helically winding a strip of sheet material. The sheet material comprises a woven fabric 10, a layer of foamed silicone rubber (not shown) and a metallic foil 14 similar to those of Figure 4 and 5. Each turn of the sheet material along the tube overlaps the adjacent turns and is secured thereto by stitches 16.

Example 1

A glass fibre braid, with an outside diameter of 22mm was coated with a two-part silicone elastomer to a thickness of 0.5 to 1mm. To this uncured silicone elastomer coating, a continuous strip of aluminium foil (2-3 nanometres thick and supported on a plastics release film) was applied by helically wrapping with an overlap of typically 1-2mm between successive turns (as shown in Figure 2). Subsequent heat curing at 130 degrees centigrade for about 5 minutes,

following by removal of the release film, gave a highly reflective and flexible tubular construction.

The product was placed over a rubber tube (as used for automotive brake hose) and the assembly mounted 50mm from a heating element at 900 degrees centigrade (simulating a hot exhaust pipe). The temperature of the inner rubber tube remained below 125 degrees centigrade, thereby avoiding damage.

Example 2

Example 1 was repeated; in this case the elastomer layer was a silicone elastomer foam with a density of about 800kg/cubic metre and a thickness of 1-2mm.

This gave a more resilient coating and made the overlying aluminium foil less susceptible to abrasion.

Example 3

As shown in Figure 3, a silicone elastomer was applied to the glass braid, exactly as in Example 1 or 2. Continuous strips 6 of foil were then applied to the uncured coating in a direction longitudinally of the braid. Four strips were used, giving an overlap of about 2mm between adjacent strips. The silicone elastomer was then cured at 130 degrees centigrade for 5 minutes.

Example 4

Braid and a single strip of aluminium film were combined using a self-foaming silicone elastomer composition, but the latter composition was applied to the aluminium foil (rather than to the braid) prior to curing/foaming of the elastomer. The strip was applied to the braid by passage through forming dies which caused the foil to be progressively folded around the tube. The product was similar to that of Example 3 but employed a single strip.

Example 5

Example 3 was repeated using a knitted glass tube, but with double the quantity of silicone foam. The product was of similar flexibility and reflectivity to those of Example 3.

Example 6

Example 3 was repeated using a rayon braid in place of glass fibre. Flexibility and reflectivity were again similar to those of Example 3.

Example 7

Silicone elastomer employed in Example 2 was used to bond aluminium foil 1 to 4 nanometres in thickness to a flat glass cloth woven from glass fibre. After foaming and

curing of the elastomer and removal of the polymeric support film from the foil, the resulting sheet material was cut into strips 90mm wide. The strips were then joined into tubing as described in relation to Figure 4. The tubing the flexible and reflective with similar properties to the tubing described in Example 2.

Example 8

Example 7 was repeated but the strips were joined into tubing as described in relation to Figure 6. This gave a more flexible tubing than that of Example 7.

Example 9

Sheet material was prepared as described in Example 7, but instead of being cut into strips, was made into a garment. The garment was found to protect a wearer from infra-red radiation while being sufficiently flexible for comfort.

CLAIMS

1. A method of making a flexible sheet material suitable for use as a barrier for resisting heat transfer from a source of radiant heat, the method comprising forming a layer of a silicone elastomer and bonding a metallic foil less than one micron in thickness to one surface of the layer by transferring the metallic foil to the elastomer layer from a supporting substrate.

2. A method according to claim 1, wherein the metallic foil is bonded to the elastomer layer by means of adhesive.

3. A method according to either one of claims 1 and 2, wherein the elastomer layer is formed on a knitted, braided or woven fabric support.

4. A method according to claim 3, wherein the elastomer is applied to a tubular fabric support.

5. A method according to claim 3, wherein the elastomer is applied to a planar fabric support which is subsequently formed into a tube.

6. A method according to claim 3, wherein the fabric support is formed from glass fibre, aromatic polyamide fibre or regenerated cellulose fibre, including blends thereof.

7. A method according to any one of claims 1 to 4, wherein the elastomer is foamed, either before or after bonding the foil thereto.

8. A method according to any one of claims 1 to 5 wherein the metallic foil is of aluminium.

9. A method according to any one of claims 1 to 6 wherein the metallic foil is less than 0.01 microns in thickness.

10. A method according to any one of claims 1 to 7 wherein the metallic foil is from 2 to 4 nanometres in thickness.

11. A method of making a flexible sheet material substantially as hereinbefore described with reference to the accompanying drawings, or as illustrated by the Examples.

12. A flexible tube made of a material made by a method according to any one of claims 1 to 11.

13. A fabric made of a material produced by a method according to any of claims 1 to 11.

14. An article of clothing made of a material made by a method according to any one of claims 1 to 11.

15. A flexible tube suitable for use as a barrier for resisting heat transfer from a source of radiant heat, the tube being formed from a flexible sheet material which comprises a layer of silicone elastomer formed on a woven support fabric, and a metallic foil less than one micron in thickness bonded to the exposed surface of the elastomer layer, the length of the tube extending at substantially 45 degrees to the direction of the weft of the woven support fabric.

**Patents Act 1977**
**Examiner's report to the Comptroller under Section 17 (The Search Report)**

Application number

9124113.3

**Relevant Technical fields**

(i) UK Cl (Edition K ) B5N, F2P, F2X

(ii) Int Cl (Edition 5 ) A62D, B32B, F16L, H02G

Search Examiner

R J MIRAMS

**Databases (see over)**

(i) UK Patent Office

(ii) ONLINE DATABASES : WPI : CLAIMS

Date of Search

24.01.1992

Documents considered relevant following a search in respect of claims 1 TO 15

| Category (see over) | Identity of document and relevant passages | Relevant to claim(s) |
|---|---|---|
| A | DD 000213597 A (VEB ASGLATEX) - eg Claim 2 | 1,14 |

| Category | Identity of document and relevant passages | Relevant to claim(s) |
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